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Project Summary

Lime Stabilization and Ultimate Disposal of Municipal Wastewater Sludges

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The report summarized here documents the successful use of lime to stabilize sludge at 28 municipal wastewater treatment plants. Sludge stabilized with lime can be simple and inexpensive and can be used as a backup or interim system, or to upgrade a system, or instituted as a less costly system. Bacterial analyses demonstrated that liming a sludge to pH of 12 is an effective means of inactivating total and fecal coliform, although organisms can regrow as the pH drops in stockpiled sludge. The lime-stabilized product can be landfilled, land applied as a liquid sludge or as a cake, or stockpiled before landfilling or land application.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The process of lime stabilization involves adding lime to wastewater-derived sludge in quantities sufficient to raise the pH of the sludge to 12.0 for a contact period of at least 2 hours. The high pH reduces levels of pathogenic (disease-causing) bacteria and viruses in the sludge and controls putrefaction and odors. The process has been accepted by the U.S. Environmental Protection Agency (EPA) as a "Process to Significantly Reduce Pathogens," meaning that lime-stabilized sludge meets minimum requirements for disposal on controlled land-application sites.*

In some areas of the country, the technique of lime stabilization and land disposal has gained in popularity as an alternative to processing sludge by heat treatment techniques or disposing of it by incineration, both of which have been affected by rising costs and uncertain availability of fuel. Many wastewater treatment plants at which lime stabilization is practiced were not originally designed for this process. The technique has been instituted by plant operators to replace more costly sludge-handling processes, to meet interim sludge-handling demands, to back-up existing techniques of sludge management, or to meet seasonal demands.

Although some design guidance is available (e.g., EPA's Process Design Manual "Sludge Treatment and Disposal"), the technique has presently been defined more by practice than by design. Consequently, the study reported here was undertaken to sample facilities at which lime stabilization is practiced and to produce a guide to serve as a practical source of information for designers, operators, and others. The Guide also describes the effectiveness of lime stabilization for pathogen kill and investigates the cost of lime stabilization.

*40 CFR Part 257. Criteria for Classification of Solid Waste Disposal Facilities and Practices. *Federal Register*, Vol. 44, No. 179, September 13, 1979.

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Survey of Plants

The investigators visited 28 wastewater treatment facilities in New England and New York at which lime stabilization of sludge was reportedly being practiced on a permanent, interim, or seasonal basis. (In fact, true stabilization (pH > 12) was not achieved at some of the plants visited; several routinely limed sludge to pH levels slightly below 12.)

Three general techniques of lime stabilization were observed:

- Adding lime to a liquid sludge before land application. Typically, this is carried out as a batch process. Lime is added to a tankful of sludge, and the lime-stabilized sludge is then pumped to a land-application vehicle for removal from site.
- Adding lime to a liquid sludge before dewatering. With the use of conventional equipment originally installed for conditioning the sludge before dewatering by mechanical means, operators simply increase the lime dose to obtain the pH levels required for stabilization.
- Adding lime to a dewatered sludge cake. Hydrated lime is added directly to a sludge-cake screw conveyor, and rotation of the conveyor serves to mix the lime and sludge.

On the average, operators applied to the sludge a dose of 20 to 25 percent lime (as CaO) based on dry sludge solids content; data from other sources indicate that this dose should be sufficient for sludges thicker than 2 percent solids. For thinner sludges, lime doses of 30 percent or more would be required.

Operators' tests for total coliform and fecal coliform bacteria indicate complete inactivation of these indicators in sludge limed to pH 12.0 and higher. Below pH 12.0, numbers of these bacteria are greatly reduced from numbers in the raw sludge, but they are detectable. Regrowth of bacteria in stockpiles of dewatered, lime-stabilized sludge can be correlated with the gradual decay in pH that occurs after several weeks.

The lime-stabilized sludge product is either disposed of in a landfill, applied to land as a liquid sludge, applied to land as a cake, or placed in stockpiles for future landfilling or land application.

Findings

Required Facilities

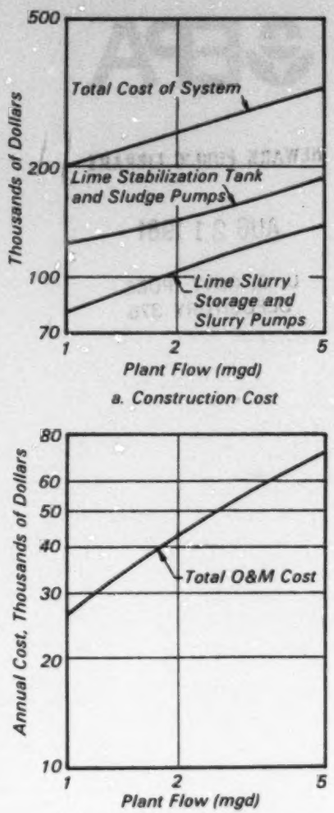
Lime stabilization can be simple and inexpensive. Required facilities consist of a dry storage area for bagged lime or a storage tank with mixer for slurry, a steel tank with a mixer and dust collector for slurry makeup (or without the dust collector if the tank is being used only for slurry dilution), a slurry metering pump, and a mixing tank to provide the necessary detention period for the sludge/lime mixture. Stabilized by this method, the liquid sludge can then be pumped directly to land-application trucks or can be dewatered before disposal.

In the simplest of systems—the batch process—only a sludge/lime mixing tank and land application truck are required. Lime slurry can be purchased when needed and used immediately. Running the system requires little training and little technical knowledge.

Suitable Applications

Lime stabilization is well suited to the sludge management requirements of smaller plants. Twenty of the twenty-eight plants visited in the study have current average wastewater flows of 0.25 m^3/s (6 mgd) or less. Of the five plants treating flows of more than 0.45 m^3/s (10 mgd), only one is practicing true lime stabilization on a full-time basis.

Two factors make the process more attractive for application in smaller plants than in larger. First, process costs are operation-and-maintenance (O&M) rather than capital intensive. Second, the costs of chemicals—a major portion of the process' total costs—show little economy-of-scale. Typical costs of lime stabilization of liquid sludge in a batch operation (the only lime stabilization method rated acceptable without qualification in this study) are illustrated in Figure 1; costs for converting and using existing lime-conditioning equipment for operation as a lime stabilization system are presented in Figure 2. These curves are derived from criteria listed in Table 1. In both cases, costs of lime are included. It is assumed that waste carbide lime is used for the batch operation and that the most economical form of lime at a given-size plant is used for the converted lime-conditioning system.



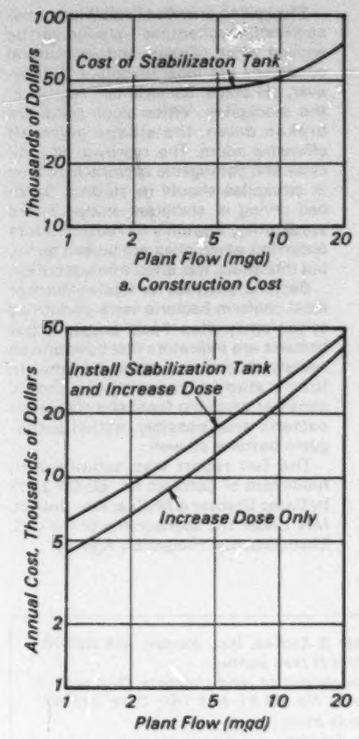
a. Construction Cost

b. Operation and Maintenance Cost

Figure 1. Cost of lime stabilization of liquid sludge in a batch operation. (mgd X 0.438 = m^3/s)

At smaller plants, similar to those studied in this investigation, lime stabilization appears to be an attractive process choice in four types of situations:

- as a back-up to the primary sludge processing operation at a facility,
- as an interim sludge management measure when new processing facilities have not yet been brought on-line,
- as a technique to upgrade or improve the degree of stabilization presently being obtained at a facility, or
- as a less costly replacement for incineration or heat treatment processes.



a. Construction Cost

b. Operation and Maintenance Cost

Figure 2. Cost of conversion to lime stabilization at a facility with vacuum filtration. (mgd X 0.0438 = m^3/s)

Back-up Systems

Because lime is widely available, suitable for storage, and often already in use at a facility in another capacity, the lime-stabilization system can be brought on-line on short notice, following relatively simple start-up procedures. When designed for use as a back-up process, the temporary operation of which can be labor-intensive without disrupting plant activity, the capital cost of the lime stabilization system is very low.

Table 1. Criteria Used for Cost Study

Sludge Production	0.24 kg/m^3 (2000 lb/mil gal) wastewater treated
Lime Dose for Stabilization	20 percent (as CaO)
Capital Cost Base	3135 (ENR, April 1980)
Capital Cost Amortization	20 years; 7 percent
Salary	$13.50 per hour (including benefits)
Electrical Cost	$ 0.06 per kwh
Maintenance	3 percent of equipment capital cost (annually)
Cost of Lime (delivered as CaO)	
Bagged Hydrated Lime	$135/metric ton ($125/ton)
Carbide Lime	$94/metric ton ($85/ton)
Quicklime	$72/metric ton ($65/ton)

Interim Systems

If an interim sludge handling system is required, lime stabilization can be done inexpensively with the use of equipment already available at the plant site. At a number of plants visited in the course of this study, lime stabilization took place in available sludge conditioning tanks, existing aerobic digesters, or unused sludge tanks, or by directly applying lime to sludge in existing sludge-conveyance systems.

Upgrading Systems

At the study sites, the operators' use of lime stabilization upgraded their existing sludge processing systems in three ways:

- The process was used to upgrade the degree of stabilization achieved by the aerobic and anaerobic digesters.
- It was applied to systems that had been disposing of conditioned, but unstabilized, sludge.
- It was instituted as a means of controlling odors.

Typically, the equipment required was either available on-site or acquired at little expense.

Replacement Systems

Rising fuel costs have greatly increased the costs of sludge incineration and heat treatment. The problem can be especially severe at smaller treatment plants, where fuel must be wasted during low-load periods to keep incinerator temperatures up. At 12 of the plants studied, with capacities up to 16 mgd, lime stabilization has replaced heat treatment processing or incineration, which had been found to be too costly.

Operational Considerations

Type of Lime

The economical form of lime depends on plant size and location. Bagged hydrated lime and lime slurry are the least expensive forms for smaller plants (up to about 0.2 m^3/s (5 mgd); quicklime is appropriate for larger plants. If carbide lime (which is a waste product) can be economically delivered, its use is appropriate for a wide range of plant sizes.

Effects of Stockpiling

Stockpiling may adversely affect the bacteriological quality of lime-stabilized sludge. Although lime stabilization results in a high coliform kill, the process does not destroy volatile sludge organics, which represent a source of food for the microorganisms surviving in the sludge. These surviving bacteria can "regrow" or can recover from inactivation if sludge pH drops and causes the sludge to become "unstabilized." Evidence of this was noted at various sites. Stockpiles of a few months to a year old, when broken down, emitted an odor signifying bacteria regrowth.

Stockpiling sludge that has been lime-stabilized, dewatered, and allowed to dry on sandbeds is a significant improvement over the stockpiling of wet cake.

* U.S. GOVERNMENT PRINTING OFFICE: 1981-757-012/7154

Land Application

Developing a successful program for applying lime-stabilized sludge to land, subject to provisions of 40 CFR, Part 257, is clearly possible. Some treatment plant operators report that farmers who had been skeptical about using the product on their lands have obtained improved crop growth and have come to welcome the availability of the sludge. In New England, particularly, where farmers routinely add lime to agricultural soils to maintain pH, use of lime-stabilized sludge reduces or eliminates the farmer's need to purchase lime.

Lime-stabilized sludge has been successfully used as a soil builder. Soils that have lost top-soil by poor management or mining practices are improved by the organic content and moisture-holding capacity of the sludge.

Operations involving land application of lime-stabilized sludge have had odor problems when stockpiled sludge was applied on a warm day. The odors, however, have been described as being less offensive than those from spread manure.

Effects of Poor Process Control

Lime stabilization systems may be subject to poor operational procedures. Because the effects of incomplete stabilization are not immediately apparent and do not occur onsite, an improper lime dose may not be recognized. In addition, where lime is added before dewatering, the lime dose required for stabilization may be confused with the dose required for sludge conditioning. This may result in a lower sludge pH than is required for stabilization. Cutting lime dose is an easy, but improper, means of cutting chemical costs.

Treatment plant operators should be educated on the goals of lime stabilization—be more aware of the importance of adding an appropriate quantity of lime to the sludge and supplying adequate mixing and detention time—to reduce problems caused by poor operation and cases of incomplete stabilization. Additionally, operators must understand that the primary goal of stabilization is not to control odors but to protect public health.

Conclusions and Recommendations

The only lime stabilization method rated fully acceptable is the addition of lime to mixed batch tanks. Adding lime before dewatering with the use of equipment intended for sludge conditioning requires close operator attention to ensure successful stabilization. Adding lime directly to dewatered sludge cake has not yet been demonstrated to be consistently effective in bacterial kills. Although both of these latter techniques offer the advantge of low capital cost, their effectiveness and reliability in killing pathogens should be demonstrated.

Stockpiling provides flexibility in land-application schedules—sludge can be applied when climatic and agricultural conditions are most favorable. If, however, pH drops, bacteria can regrow in the stockpiles. When such piles are broken down, the sludge gives off offensive odors. The regrowth of indicator and pathogenic bacteria over time in stockpiles should be studied. Sand-bed drying of stabilized sludge before stockpiling appears to reduce odors occurring when piles are broken down, but this effect, too, should be quantified.

Bacteria analyses for total coliform or fecal coliform bacteria were performed at the study sites. Fecal streptococcus bacteria are indicators that have proven resistant to inactivation by lime. In future studies, researchers should consider studying fecal streptococcus bacteria and, possibly, actual pathogenic bacteria as well.

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The complete report, entitled "Lime Stabilization and Ultimate Disposal of Municipal Wastewater Sludges," (Order No. PB 81-198 160; Cost: $15.50, subject to change) will be available only from:

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